Stone (A. K.)

THE HYGIENIC ARGUMENT FOR CREMATION

Considered from a Bacteriological Standpoint.

BY

A. K. STONE, M. D.

Reprinted from the Boston Medical and Surgical Journal of November 2 and 9, 1893.

presented by the author

LIBRARY

BOSTON:
DAMRELL & UPHAM, PUBLISHERS,
No. 283 Washington Street.
1893.

S. J. PARKHILL & CO., PRINTERS
BOSTON

THE HYGIENIC ARGUMENT FOR CREMATION CONSIDERED FROM A BACTERIOLOGICAL STANDPOINT.[1]

BY A. K. STONE, M.D.

At the time when the cremation movement was in its infancy the need for some immediate change in the mode of the disposal of the dead was manifest, and the evils of intramural burial everywhere acknowledged. Thirty years ago few of the cities of the old world had any common water-supply. The inhabitants for the most part depended upon wells. These were frequently contaminated, and often became sources of epidemics; and it was much easier to lay the charge to some neighboring cemetery, than to the contamination of such wells by the sewage from neighboring houses. For, should the latter be proved, individual interests must be sacrificed and actual hard cash must be paid out by the owners of the adjoining property in order to remedy their defective drainage.

At present there are few cities of any size where there is not a general water-supply, and any contamination which produces anything like an epidemic arouses the citizens, and the boards of health are ready to see to it that the source of contamination is found and stopped, never minding the cost or discomfort of a few individuals.

The overcrowding of most of the churchyards gave great plausibility to this argument. The churchyards were usually small plots of ground around the church, and had been in use for very long periods of years. Usually they were in parts of the towns or

[1] Read before the Warren Club.

SURGEON GEN'L'S OFFICE
LIBRARY

cities where the population was especially dense, and where improvements in sanitation were slowest to make progress. Again, their use had gradually become confined to burials of the poorer classes from the neighboring parish, and single individual graves were very rare. In London it was the general custom to dig a deep grave, usually having to bore with a long auger to find a place where such a grave could be made without disturbing coffins still in a good state of preservation. When these deep common graves had been dug, they were kept open, or loosely covered with boards until such a time as it was filled to within a couple of feet to the top, the last coffin was then covered with a foot and one-half to two feet of earth. In fact, in London alone, with its immense population, the churchyard area in 1849 only amounted to about 218 acres, and in this there were annually over 50,000 bodies buried. Such a number would cause the whole space to be filled completely with bodies each decade.

The same condition of affairs was to be found all over the Continent, where the conservatism of the people and the scarcity of land caused the same graveyards to be used for centuries.

In this country the older graveyards in many of the cities became overcrowded early in this century, the most notable case being Trinity Churchyard in New York. Here the soil was so shallow that it was impossible to dig a grave so that the body should be more than eighteen inches to two feet below the surface. During the Revolutionary War the Hessians were employed to cover the churchyard with several feet of earth. Yet in spite of this, in the early part of this century, the stench from this graveyard was extremely bad; and during the cholera epidemic of 1849 the disease seemed to have a focus about this burying-ground. Several of the other old churchyards in New

York and Copp's Hill Burying-ground in Boston became overcrowded, and had to be closed against further interments.

In spite of this horrible condition of affairs common to many places during the middle of the century, the number of epidemic diseases actually attributable to cemeteries is very small indeed. Adams, in the Sixth Annual Report of the Massachusetts State Board of Health, states that after a careful study of the reported epidemics due to graveyards, he only found two that were at all credible. One of these was in Barbary and the other in Italy; and from the account of the latter, it is doubtful whether it would stand the light of modern investigation. A circular sent at this time to five hundred physicians, evoked only eleven positive replies. Of the five in Massachusetts, four would not stand investigation, and the other could not be inquired into, because of the physician's having left the State. Of the answers to Dr. Adams from abroad, in one the deleterious influence was thought to be due to an overcrowded churchyard; but in this case no wells were involved, and the evil effects probably came from the foul air.

Dr. Cameron, Professor of Hygiene in Dublin, while having known of several cases of illness due to neighboring graveyards, and of several wells that were undoubtedly contaminated with nitrogenous material from similar sources, says: "I am disposed to believe that the injuries arising from badly kept graveyards are to be attributed to a far greater extent to the foul air, than the contaminated water. If the latter be very foul, it will, of course, produce diarrhœa, lowering the vital powers, and other effects caused by water containing simple decomposing organic material. I am of the opinion that water tainted by graveyards does not cause typhoid fever, or other zymotic disease."

Mr. Holland, Medical Inspector of Burials of England and Wales, states that in properly regulated cemeteries he has known of no sickness which appeared to be induced or aggravated by any such cemetery, though in overcrowded graveyards he had had numerous instances of mischief done to the inhabitants in the neighborhood.

In the same year (1874) Baginsky[2] could not discover a single case where the vicinity of a graveyard had caused an epidemic. Further, a series of investigations were made in regard to the chemical conditions of the water in the wells of churchyards in various cities by Wernher,[3] in which he found the water of the churchyards was purer than the wells of the town. Müller[4] also reaches the same results after a very complete investigation. Adams quotes from Professor Fleck[5] of Dresden, who in 1872, from the month of June to September, examined carefully the water from the nine wells of the cemetries, and also from the wells in the town. First, no injurious physiological effects from the cemetery water came to the author's notice, although in many instances the water of the wells was in constant use by the families of the gravediggers. In general there was no essential difference between the average well-water throughout the city of Dresden and the analysis of the water from the nine wells in the cemetries. In Paris, water from a well near a cemetery had a sulphur-like taste, and was bottled and sold as a mineral water and obtained considerable repute.

Zulger alone, to the contrary, reports a typhoid

[2] Leichenverbrennung von Standpunkt Hygiene. Quoted by V. Esmarch, Berlin, 1874.
[3] Wernher: Bestattung der Todten. Quoted by V. Esmarch,
[4] Schädigen die Kirkhöfe def Gesundheits der Lebenden, 1887. Quoted by V. Esmarch.
[5] Professor Fleck, 1893. Quoted by Adams.

epidemic from a graveyard in Berlin in 1873. But a sanitary committee of Berlin (1882–1885) could not find that the burial places exerted any influence either upon the production or spread of typhoid fever.

All of this goes to show that no serious epidemics have been attributable to graveyards, even during the period in which there was the best chance for such to have taken place, owing to the utter disregard of sanitary laws and to the great overcrowding of the burial grounds.

Since 1880, a period in which there has been the greatest activity among scientific men in their desire to discover sources for disease and epidemics, I have been unable to find any well authenticated case of epidemic coming from any burial place, although an epidemic of cholera in Spain is reported as coming from an old graveyard where the victims of previous epidemics had been buried. From what we know of the source and origin of cholera, it does not seem probable that this case will stand investigation.

With the development of the science of bacteriology, a new force was given to the arguments of those who believed in cremation. The bacteria were the cause of disease. The body of the person, when buried, carried with it into the earth the pathogenic bacteria. These escaped from the body, found their way into the neighboring subterranean water-ways, and carried pestilence to the wells and water-supplies. Such was the *a priori* reasoning and it seemed extremely plausible. Therefore a number of attempts have been made to investigate the condition of the soil in its relation to germ life.

The first series of experiments of importance was made incidentally in the course of experiments made to determine the etiology of the anthrax. It was found by Pasteur that in fields which had not been

used for pasturage for many years on account of previous occurrence of anthrax, when new herds were again let into the fields they were soon attacked by the anthrax bacilli and the plague again appeared. He accounts for this by the fact that the bodies of the animals which had died during the previous epidemic had been buried in the field, that the spores of anthrax had formed in their bodies, and that these spores had been brought to the surface by earthworms and were then taken up by the animals feeding on the grass, etc.

Koch, however, in his article, showed by a series of seven experiments that it was very rare that earthworms acted as carriers of spores. He placed a number of earthworms in a pot of earth filled with spores of anthrax, and then with precautions against contamination, inoculated mice with the contents of the intestinal canal of the worms. The time that the worms had been in the earth which contained the spores varied from five days to one hundred and ten days. In all the control experiments where the mice were inoculated with small particles of the earth, they died on the following day of anthrax, while only one of the mice inoculated from the earthworms died, and that was on the third day. The possibility of contamination from the earth adhering to the worm must, of course, be considered in this case.

But even if the earthworms may be poor carriers of the bacteria, Koch further showed that it was highly improbable that spores could form in the lower levels of the surface of the earth, where the animals would naturally be buried, on account of the permanent low temperature. Also, while it is unusual, if indeed it ever occurs, for spores to form in the living body during life, there were plenty of chances for spore formation to take place on the surface of the soil, which was always smeared more or less with the bloody discharges

of the diseased animals, if it was not soaked with the infected blood of the animals, which were rarely allowed to be buried before their hides were removed. Hence, the earth's surface and the grass could be the source of the later epidemics. It is to be remembered that dead bodies are usually buried much deeper than the ordinary habitat of the earthworm. And moreover, earthworms do not feed upon dead animal material.

All of these arguments go to disprove Pasteur's earthworm theory and we are obliged to give up the supposition that spores are brought to the surface for the infection of man and animals by any such agency.

Koch's work was later substantiated by Kitasato, who made a series of observations [6] upon the possibility of spore formation in anthrax. He took, with aseptic precautions, the blood of mice that had died of anthrax and inoculated gelatine and agar tubes and placed them in the earth at various depths. This he repeated each month in the year, and a record of the temperatures at the various depths was carefully noted. Control tubes were made and kept at the room temperature, but no spore formation was seen in any of these cultures. From the results of these experiments it was shown that the anthrax bacilli at the depth of one-half a metre during June, July and August, and at a depth of one and one-half metres during July alone, formed spores. At the latter depth only a very few appeared. Also, during July, a few bacilli grew at the depth of two metres, but they had no spores; while at three metres below the surface there was no growth at any time. In other words, no bacilli of anthrax showed any growth when the temperature was lower than 14° C. At 15° C. a few spores began to be formed. No bacilli were found alive after a stay

[6] Zeitschrift für Hygiene, 1890, vol. viii.

of four weeks in the ground, and some of the cultures were dead at the end of a week, others at the end of two weeks. If bacteria of decomposition were added, no anthrax could be found at the end of a week, even during July and August, at a depth of one and one-half to two metres.

Heser [7] investigated the bodies of sheep, goats, cattle and horses buried in the ground at various depths, which after a certain time were exhumed and examined for virulent bacilli by inoculation upon other animals. In this series there was, with one exception, a negative result, although a goat was dug up on the fourth day, a cow on the seventh, and another cow on the ninth day. The exception was a sheep, which lay for fourteen days in winter at a temperature of 6° to 8° C.

V. Esmarch also made a series of experiments with the bodies of animals placed in different conditions, buried in loam, in sand, at various depths, and also kept in water, the ice chest, the constant temperature apparatus and in the free air. In only one single case did the bacilli survive the death of the animal eighteen days, and that was in the body kept in an ice chest All these experiments were conducted to exclude oxygen as far as possible. To prove that spores were not formed in the bodies, a piece of meat was taken and also the body of a mouse. Into each of these spores of anthrax were introduced, with the result that after seventeen or eighteen days, inoculation showed the presence of the anthrax bacilli, thus proving that when spores were present before burial that they remained virulent.

It will be seen that all this work goes to support the original assertion of Koch, that spore formation rarely took place beneath the soil or in decomposing animals.

[7] Zeitschrift für Thiermedicin., 1877. Quoted by V. Esmarch.

Therefore the bodies of such animals are not a source of infection, if deeply buried.

What is true of anthrax is also true in a great measure of other specific, pathogenic organisms and the possibility of danger of infection in other diseases is lessened, because in a few of the ordinary bacterial diseases does the pathogenic bacteria form spores. V. Esmarch further concludes from his investigations that the greatest number of pathogenic bacteria probably cease growing soon after the death of their victim (though Fraenkel and others had previously observed that a decided increase for a short time took place in certain cases). The disappearance occurs more rapidly the faster decomposition progresses. The specific bacteria are probably simply killed by the more vigorous growth of the bacteria of decomposition, by the absorption of oxygen and chemically by the production of products unfavorable to their development.

A similar set of investigations were undertaken by Dr. Petri,[8] and extended over a period from 1885 to 1891. It was his purpose to find out how much the dead bodies of animals, which were known to be full of pathogenic bacteria, were a source of danger to the living.

In all such cases the question necessarily arises, how far the deductions which are made from the bodies of small animals can be applied to larger animals. But so far as there has been any chance for comparison between the experimental animals and sheep, cattle, etc., there has been no great variation. Petri's experiments were made with the bodies of mice, guinea-pigs and rabbits, and were conducted with the greatest care, and, whenever possible, control experiments were made. The internal organs of the animals were exam-

[8] Dr. Petri: Arbeiten aus den Kaiserlichen Gesundheits Amt., Bd. vii, 1891.

ined; also the fluids in the coffins and the soil about the coffins.

Anthrax experiments were made on the bodies of mice. The first was buried in sterile earth and kept moist with sterile water. After fifty days they were disinterred and one of two mice inoculated from the internal organs died of anthrax after seven days, showing a very low state of virulence. In the other case, it was supposed that anthrax was found in the cover-glass preparations, but neither the plates nor the inoculated animals showed the presence of live anthrax. In one case, after a lapse of five years, one month and eleven days, one out of six inoculations gave a positive result, but neither feeding or plate cultures gave a similar result. In some manner spore formation must have taken place.[9]

Next, sixteen guinea-pigs were buried in wood and zinc coffins, which were exhumed and examined from time to time. These were buried in a chest, with about 15 to 20 c.m. of earth over them, and kept moist and at a temperature which varied from 5° to 19° C. Out of the sixteen experiments, three gave positive results. The first after three months, in wood; the second in a zinc coffin, after six months, two days; and the third after a period of three years, ten months (46 months). Inoculated with fragments of liver, two mice remained well, while two guinea-pigs died (!). In all the corresponding zinc coffins, the fluids and the internal organs remained perfectly sterile, so far as aërobic bacteria were concerned.

CHOLERA.

Nineteen guinea-pigs were killed with cholera ba-

[9] It may be well to note that the depth of burial was not sufficient to shut out all possibility of the presence of oxygen. Also, as post-mortem examinations were made in all cases, the internal organs were exposed to the action of oxygen to an exceptional degree, and therefore spore formation was made possible.

cilli and buried in wood and zinc coffins. From the wood positive results were reached on the sixth, seventh and nineteenth day, and in the zinc on the eleventh and twelfth days; afterwards negative. Also two animals were buried free, and being exhumed, one on the seventh day, and the other after three months and nineteen days — both gave negative results. Two were also put into water and allowed to stay, the first eighteen days, and the second two months and ten days; and neither the water nor the bodies showed any bacilli. An animal buried for two months and a half in very moist earth, was exhumed at the end of that time, and neither the soil nor the cadaver showed any signs of the cholera bacilli.

TYPHOID.

Twelve rabbits were killed and injected through the aorta with a bouillon culture of typhoid, and the presence of the bacilli in the extremities was demonstrated. These bodies were buried in a sandy hill in wood and zinc coffins. All the investigations gave a negative result. There was even no discoloration of the beautiful yellow sand; and though large numbers of the bacteria had been present, they could never be found, even in the fluids which could not escape from the zinc coffins.

TUBERCULOSIS.

Twelve extremely tuberculous rabbits were buried in wood and zinc. At the end of twenty-two days, and of two months and five days, the exhumation gave positive results. That which took place at the end of five months and six days gave positive results in the zinc alone, and after that the experiments were negative.

In general, it may be said that the fluids in the zinc coffins rarely contained the pathogenic bacteria. And

in no case did the earth that had been soaked in the decomposing fluids, show the presence of the pathogenic bacteria. This is of special importance as regards the spread of disease through water-ways; and the question of whether the pathogenic bacteria last a few months more in a large cadaver is of little consequence as compared to this question, which can hardly be affected by the size of the animal. [This conclusion is not altogether in accord with the results of sewage filtration experiments, where it has been shown that the filter beds should be frequently renewed, or allowed to lie idle, in order to have perfect filtration. So under unhygienic conditions, where rapid decomposition takes place, it is possible to imagine a soil so overcharged with animal matter as to transmit bacteria direct to the ground-water.]

There remain to be spoken of only the various experiments that have been made to determine the number of bacteria in the soil. The first of these were open to serious error because of faulty technique. But Fränkel[10] and Reimer,[11] the former working on the sandy soil of Berlin, and the latter on the heavier soil of Jena, have arrived at practically the same conclusions in regard to the bacteria in the soil, namely, that the number on the surface was very large, and the diminution from this amount was very rapid, especially after the depth of three-fourths of a metre was reached; and at one and three-fourths metres the numbers were very small indeed. Or, as Reimer puts it, to a certain depth the number of bacteria is very high, but always less than are to be found on the surface. With increasing depth there is a sudden and sharp decrease of the number. The zone in which this sudden diminution takes place is, in both Berlin and Jena, between

[10] Fränkel: Zeitschrift für Hygiene, vol. ii. 1887.
[11] Reimer: Zeitschrift für Hygiene, vol. iii, 1889.

one and two metres. The exact position of this zone depends on the condition of the soil, as, for example, the line is deeper in cultivated than in virgin soil. At a depth of two metres the soil can be germ free (of aerobic bacteria). More rapid growth is observed in specimens taken from the upper strata than in those from lower.

The ground-water seems to have various influences upon the condition of things. In some cases the regular diminution took place in spite of the presence of the ground-water; in other cases there was a marked increase in the number of germs when the ground-water was reached. So that the conditions of the porosity of the soil and the amount of foul matter poured upon it probably influence the number of bacteria to be found in the ground-water.

An interesting portion of Reimer's investigations is that made in the cemeteries of Jena and Little Jena. Examinations were made in seven graves, which have been in use for from one and one-half to thirty-five years; also a set of control experiments were made in the ditches in neighboring gardens. It was found first: That the number of bacteria in the ground of the graveyards and the gardens was practically the same, though in both cases larger than in ground that had never been disturbed. As soon as a depth was reached where the earth had never been moved, the figures promptly fell to correspond with those of similar depths of virgin soil. The earth immediately below the coffins in the exhumation, showed a marked increase in the number of bacteria over the average of similar depths, yet considering the circumstances, the increase was smaller than was to be expected: while at a distance of half a metre below the coffins, the number of bacteria returned to the average that was to be expected at that depth. At a level of the upper sur-

face of the coffins there was no increase from the average in the number of bacteria found.

Beumer (although his technique is open to criticism) has also similar results to those of Reimer. He did not, however, carry his investigations as far as could be wished, for he made no examination of the earth below the level of the coffins, that is, six feet.

Gärtner [12] also derived similar results from an investigation of two cemeteries.

In 1890, investigations were begun to determine the hygienic condition of the cemetery of the Charité Hospital [13] in Berlin. No burials had taken place since 1859, and the government wished to find out whether the cemetery could justifiably be used for building purposes. Proskauer was detailed by Koch to conduct the investigations, and the results of his work are briefly as follows:

At a depth of 1.70 metres the soil is rich in human remains and remnants of coffins. The decay of these human bodies has been so complete in the last thirty-one years that in the upper layers of the earth there was no difference to be discovered, either chemically or bacteriologically, from earth that had never served for graveyard purposes. The chemical investigation at a depth of .5 to 1.50 metres, that is, directly at the level that the coffins had occupied, showed that the earth was in no ways overladen with rotting organic material, and that on the contrary it was poorer in nitrogenous material than Flüge had found in the *aufgeschütteten Boden* — heaped-up earth — of Berlin. From 1.70 metres or from two to six metres in depth, the condition of the soil was similar in all respects to what would be expected in similar soils. There was not the

[12] Gärtner: Tageblatt der Naturforscher-versam burg, 1889. Quoted by Prokann.

[13] Proskauer: Zeitschrift für Hygiene, vol. xi, 1891.

slightest trace of nitrogenous matter and no micro-organisms.

The ground-water of the graveyard and the well-water had the same chemical properties as the water from the surface wells of Berlin, all of which contain large amounts of nitrogenous compounds, particularly nitrates. But Proskauer is of the opinion that the ground-water is already contaminated before it reaches the cemetery, and that there is no increase in the amount of organic matter during its stay within the boundaries of the old graveyard. The ground-water also showed itself free from micro-organisms; and finally Proskauer concludes, after taking everything into consideration from a hygienic standpoint, that there is no reason why the Alter Charité Kirchhof should not be used for dwellings or for hospital purposes.

The work of Domingos Freire, of Brazil, in his investigation of the causes of yellow fever, is frequently quoted as giving strong arguments in favor of cremation. He has stated that he has surely found the micro-organisms causing yellow fever; that he has recognized the same organisms in the earth of cemeteries in which the yellow-fever patients have been buried; and he has also claimed to have found a method of vaccination.

Sternberg,[14] Deputy Surgeon-General of the United States, after a series of investigations into the etiology of yellow fever, was not able to agree with Freire. And in his report, 1888, he states that no such micro-organism as described by Freire, or as shown by him to Sternberg, is to be found in the blood and tissues of yellow-fever patients. In later reports he concludes that the specific infectious agent of yellow fever has not been demonstrated. The most approved bacterio-

[14] Sternberg: Manual, 1892.

logical methods fail to demonstrate the constant presence of any particular micro organism in the blood or tissues of yellow-fever cadavers. This position is supported by Cornil and Babes in their work on "Les Bacteries," who do not consider that, at the date of their publication, 1890, any specific bacteria of yellow fever had been discovered. Therefore, we are forced to the position that, until further work has been done, Freire's work cannot be taken as authority.

Professor Graucher, of the Faculté de Médecine de Paris, and Professor Richard made a report to the International Congress of Hygiene and Demography, on the Action of the Soil on Pathogenic Bacteria. They reached the following conclusions:

Pathogenic bacteria are everywhere deposited only in the superficial layers of the soil; from .5 metres to 1.5 metres there are very few present. They multiply with difficulty in the ground, though in the spore state they may remain for a long time.

The pathogenic germs are destroyed, partly by the action of the saprophytic bacteria, and partly — when they are on the surface — by the action of the sun; the latter must be considered a powerful destroying agent. Continuous cultivation of the soil, which tends to bring bacteria from the lower depths to the surface, is the very best means to bring about the destruction of the pathogenic bacteria.

Disturbances of the earth's surface — for example, extensive excavations — put in circulation a large number of pathogenic germs. A solid layer of two or three metres of earth is usually sufficient to protect the ground-waters against contamination of pathogenic bacteria.

All the investigations above quoted correspond in a remarkable degree; so that we are justified in saying that, from a purely bacteriological standpoint there is

no evidence that a buried body is a source of special danger to the living.

On the other hand, there can be no doubt that water and air are frequently contaminated by the presence of putrefying animal remains, as instanced in the analysis of well-water from cemeteries; as we see by reports of the well near Paris, which became distinctly foul shortly after the interment of the bodies of a large number of Prussian soldiers who had died of typhoid; or the story of the well in Paris where the water, contaminated by cemeteries, had a distinct taste of sulphur, so that it was bottled and sold as a mineral water; or from the undoubted cases where epidemics were of the greatest intensity in the near vicinity of overcrowded graveyards.

Why these occurrences have taken place, and what effect the decay of animal matter has upon the human being, we have at the present time no accurate means of knowing. Such data as we have can only be obtained when we study the subject of putrefaction. We cannot hold the old explanation that putrefaction is simply oxidation — the burning of the animal, in the same way that a bit of the animal would act if it were exposed to the flame. But decay, and the return of the body to its final elements, is not a simple chemical process, as is usually imagined, but a very complicated process, induced for the most part by the action of various bacteria upon the organized tissues, converting them into mid-products. The first stages, according to Flügge, consist in the change of the albumens into peptones, and this may be effected by a large number of bacteria. Among the products of putrefactive fermentation are carbon dioxide, hydrogen, nitrogen, hydrosulphuric acid, phosphoretted hydrogen, methane, formic acid, acetic acid, butyric acid, valerianic acid, crotonic, glycolic, oxalic, succinic, propionic, lactic and

amidostearic acids, leucin, ammonia, ammonium carbonate, ammonium sulphide, trimethylamine, propylamine, indol, skatol, tyrosin, neuridin, cadaverin, putrescin, cholin, neurin, peptotoxin and various other volatile acids and ptomains.[15] These special products are not necessarily all present in any given body in the process of dissolution, but vary according to the place where the body may be put, or according to the presence of certain varieties of bacteria.

The nitrification of the organic products is also due to the presence of bacteria; and within a short time two observers, quite remote from each other, have isolated a bacterium, which if not identical, is at any rate of the same species. I refer to Jordan's work at Lawrence, and Winogradsky's at Zurich. Similar work has also been done by Frankland and Warington. Thus far, bacteriological investigations have been confined to those bacteria which accomplish their work in the presence of oxygen, or to the aërobic bacteria; and but little attention has been given to those which work only when oxygen is excluded, the anaërobic bacteria, although it is known that the foul odors of putrefaction belong, for the most part, to the latter class. In none of the investigations above quoted were there attempts to discover the number of anaërobics that might be present, with the exception of the work of Proskauer, who said that some of the human remains were examined for anaërobic germs, but with negative results.

It is believed by men interested in sanitary questions, that sewage containing excreta and animal impurities, and micro-organisms, is best rendered pure by pouring it out on the soil and allowing it to percolate slowly through the upper layers, where it is met by the bacteria of decomposition which are present, as has been

[15] Sternberg: page 134.

shown above, in great quantities. The retrograde changes then take place with great rapidity, and the whole process is hastened by the action of the sun and by the cultivation of the land; the plants seizing upon the particles of decomposing matter, as soon as it is reduced to the stage where it can become their food.

The difference between this process, which is advocated by many of the best sanitary authorities at present, — as instanced by the many sewage farms in operation, among which may be mentioned Berlin, Paris, and the towns of Framingham and Marlboro in this State, and the Experiment Station of the Massachusetts Board of Health where so many careful experiments have been carried out, — and the process that takes place where a body is buried in six feet of earth, is that in the case of the former, oxygen is always present, while in the case of the dead bodies oxygen is practically excluded; the argument being that the decomposing changes in the case of the sewage take place rapidly, because the bacteria have plenty of oxygen, which is necessary for their development. On the other hand, the dead bodies are buried so deep that all supply of oxygen is cut off, and decomposition does not take place,[16] or takes place so slowly that more of the poisonous mid-products of decomposition are allowed to form, and hence the body becomes a source of danger to the living by those soluble products of decomposition designated by the general name of ptomains, or appearing in the chemical analysis combined under the general heading of albuminoid ammonias.

The only experiment which I have been able to find,

[16] Seymour Haden reported that in 1875, when removing corpses from St. Andrew's churchyard to Ilford Hollow Hill, London, the bodies were in much the same state as when first buried, and decomposition was practically arrested, and that there was little difference discernible between the first corpse of yesterday and of King Charles II's time. International Congress of Hygiene and Demography, 1891.

that bears directly on the occurrences which take place when a body is buried, is the one which is reported by the State Board of Health.[17]

A tank twelve feet in height was taken and filled to a depth of six feet with layers, first of coarse gravel, then of sand and loam from a cemetery. This was watered weekly, and the condition of the water noted. In December, 1889, the body of a dog weighing eleven and one-half pounds was put into the tank and buried beneath similar soil for the remaining six feet. This tank was watered regularly with an amount of water slightly larger in amount than what would correspond to the average rainfall on the same area. The outlet was tapped, and the escaping water was examined monthly for the space of two years. For six months practically no nitrification of the body had taken place. At the end of that time, there was an increase in both the nitrates and nitrites, and the free ammonia increased rapidly for the next five months, showing 26.625 parts per 100,000 by November, 1890. It then gradually fell off, but at the end of twenty-four months the amount was still 4.75 parts per 100,000. The albuminoid ammonia, in which the dangerous mid-products are represented, if present, increased but little for seven months, and then increased some for two months, after which it increased very rapidly, and for November, 1890, averaged 2.8000 parts per 100,000. From this time on there has been a steady fall, until December, 1891, there was but .1200 per 100,000.

The odor at the effluent grew very strong and offensive through April, May and June, and was most nauseating during the first part of July. Since then it has decreased, but all through the second year it had a strong, offensive odor. In December, 1890, the outlet

[17] Massachusetts State Board of Health Reports. Purification of Sewage, 1890–1891.

was trapped, and in this way all possible supply of oxygen entering from below was cut off. The most important effect of this proceeding was, that the number of bacteria per cubic centimetre in the effluent water immediately fell off, and from 4,319 in September, 18,360 in October, 4,796 in November, the number became 96 in December, 362 in January, 10 in February, 52 in March, and has since never been above twenty; and for several months in midsummer was sterile.

This experiment bears out what has been said above, and tends to shift the burden of proof upon the chemists, calling on them to explain what the deleterious effects of drinking-water, which is contaminated with decomposing animal matter, may be.

I conclude, from a study of the effects of bacteria contained in dead bodies upon the health of living persons, that there is no good evidence whatsoever to show that, if the bodies are suitably buried, the bacteria which are probably the cause of the so-called zymotic diseases, can in any way contaminate the ground-water. The harm which decomposing human bodies may exert upon the living must be due, not to the specific pathogenic bacteria, but to poisoning of the air and water by the presence of volatile and soluble substances, which probably have the effect of depressing the general vitality of the persons subjected to the influence.

Under suitable conditions, the earth, with the assistance of the "bacteria of decomposition," appears to be a rapid and sure means by which bodies of persons dying of zymotic diseases may be rendered harmless and converted into material suitable for the maintenance of higher vegetable life.

Experience goes to show that the pathogenic bacteria are unable to resist for any length of time the chemi-

cal changes set up in the dead body by the bacteria of decomposition, excepting in the few rare cases, where spores are formed. These are able to resist the putrefactive changes for an indefinite period of time.

At the request of a gentleman who is much interested in cremation, I undertook the task of going over the literature which has accumulated upon this subject and have tried to find out from a bacteriological point of view what arguments could be advanced in favor of cremation. The conclusions reached are not at all in accord with my preconceived ideas, and it appears as though it belonged to the chemists and not to the bacteriologists to prove, if possible, that cremation is a hygienic necessity. Of course economical and æsthetic arguments are entirely uninfluenced by the lack of evidence to support any given hygienic argument.

THE BOSTON

MEDICAL AND SURGICAL JOURNAL.

A FIRST-CLASS WEEKLY MEDICAL NEWSPAPER. PUBLISHED EVERY THURSDAY.

Two Volumes yearly, beginning with the first Nos. in January and July. But Subscriptions may begin at any time.

This JOURNAL has been published for more than sixty years as a weekly journal under its present title.

Still it is incumbent upon this JOURNAL, no less than upon others to assure its patrons from time to time, as the occasion arises, of its desire, ability, and determination to meet all the requirements of the most active medical journalism of the day, without sacrificing any of that enviable reputation which is an inheritance from the past.

It is under the editorial Management of Dr. George B. Shattuck, assisted by a large staff of competent coadjutors.

Communications from all quarters of the country are acceptable. Liberal arrangements are made for reprints of original articles, and for such illustrations as serve to increase their value or interest.

All editorial communications, and books for review, should be addressed to the Editor.

Subscriptions and advertisements received by the undersigned, to whom remittances should be sent by money-order, draft, or registered letter.

Terms of Subscription: In the United States, and to Canada and Mexico, $5.00 a year in advance. To Foreign Countries embraced in the Universal Postal Union, $1.56 a year additional. Single numbers, 15c. Ten consecutive numbers free by mail on receipt of $1.00.

Sample copies sent free on application.

PUBLISHED BY DAMRELL & UPHAM,

283 Washington St., Boston.